Extreme Dust Depletion in Two Intervening Quasar Absorption Line Systems with the 2175Å Galactic Extinction Bump at z~1.4

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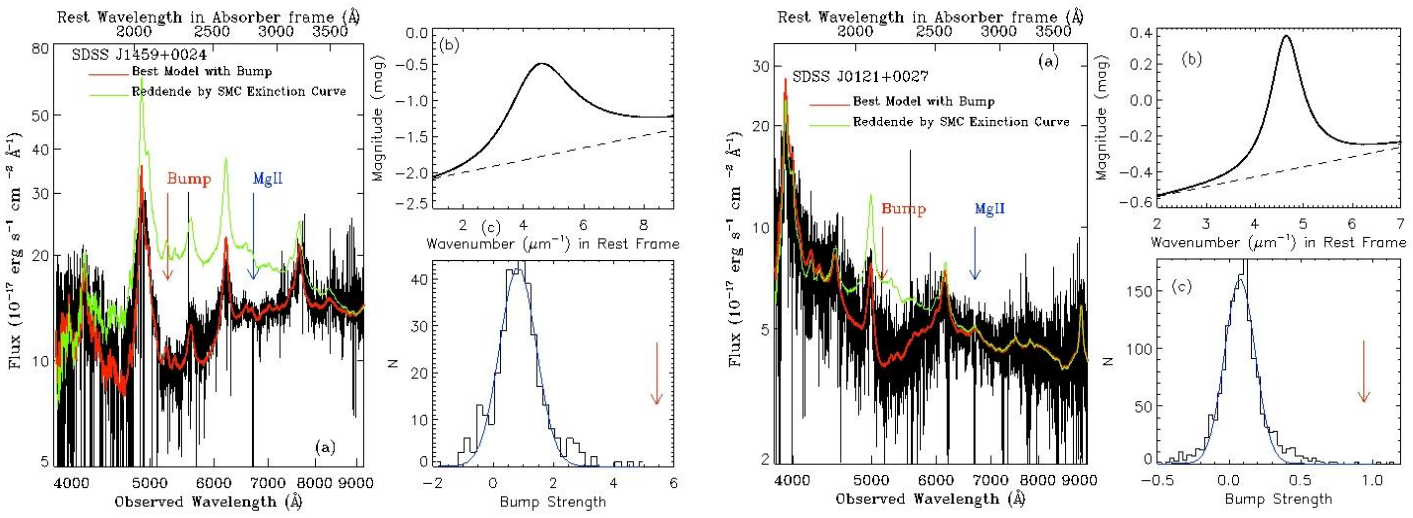
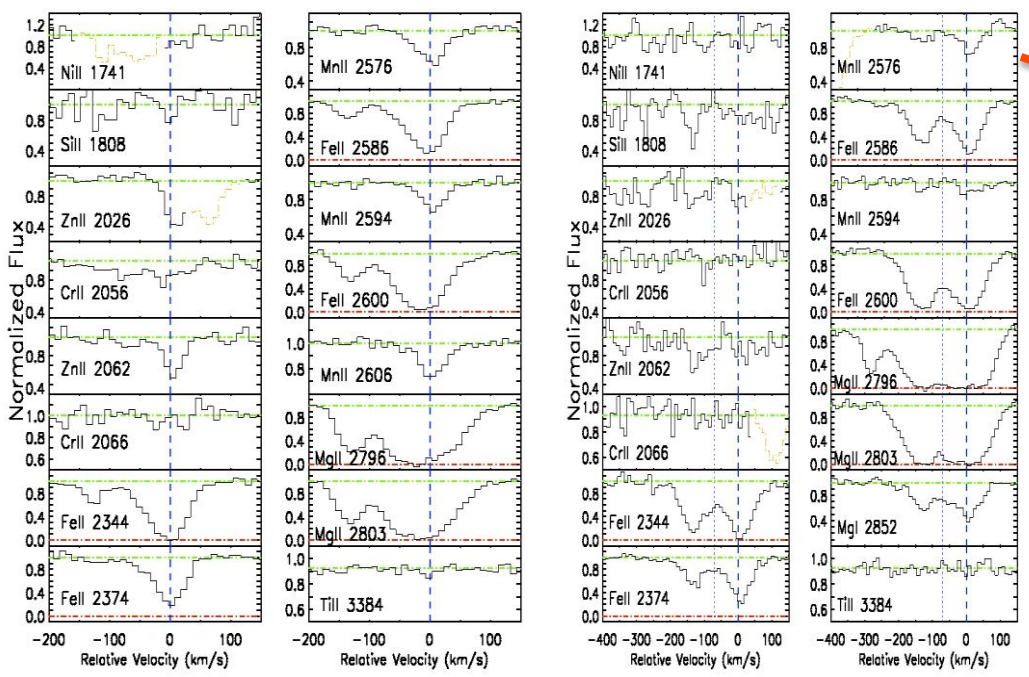
Abstract

We present the column densities of heavy-elements and dust depletion studies in two strong MgII absorption systems at z~1.4 displaying the Galactic 2175Å dust extinction feature. Column densities are measured from low-ionization absorption lines using Apparent Optical Depth Method on the high signal noise ratio Keck spectra. We find the dust depletion patterns resemble to that of cold diffuse clouds in the Milky Way (MW). The values, [Fe/Zn] ~ -1.5 and [Si/Zn] < -0.67, are among the highest dust depletion measured for quasar absorption line systems. Moreover, we find a moderate anti-correlation (Spearman's ρ= -0.46) between the abundance ratio ([Fe/H]) and the relative strength of 2175Å absorption in 15 lines of sight in MW. We conclude that heavy dust depletion (i.e. a characteristic of cold dense clouds in MW) is required to produce a pronounced 2175Å extinction bump.

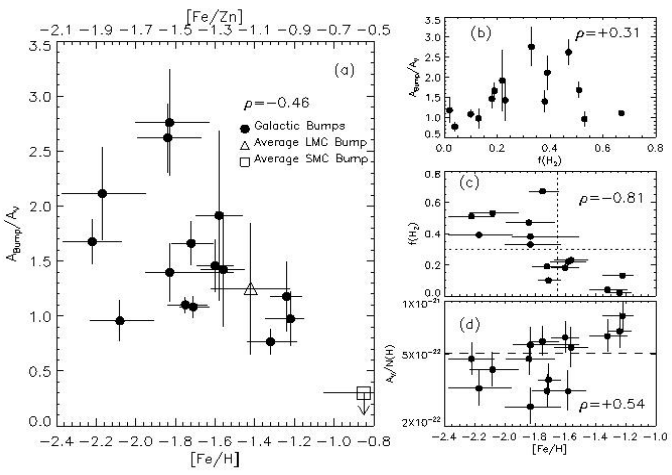


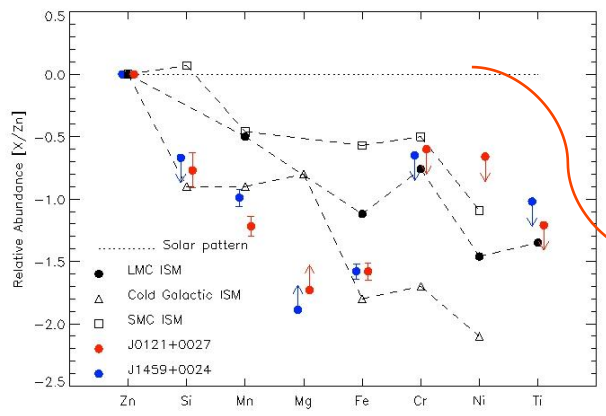
The best fitted extinction models for J1459+0024 and J0121+0027.
(a). Red solid line is the best fitted model. Red arrow indicates the center of extinction bump and blue arrow indicates the MgII absorption lines. Green solid line is reddened composite quasar spectrum by using a SMC type extinction in the rest frame of absorber. It is overplotted for comparison with the best model to emphasize the extinction bump.
(b). The best fitted extinction curve
(c). Histogram of fitted bump strength of the control sample. The blue line is the best fitted Gaussian profile. Red arrow indicates the strength of bump derived from interested absorbers.



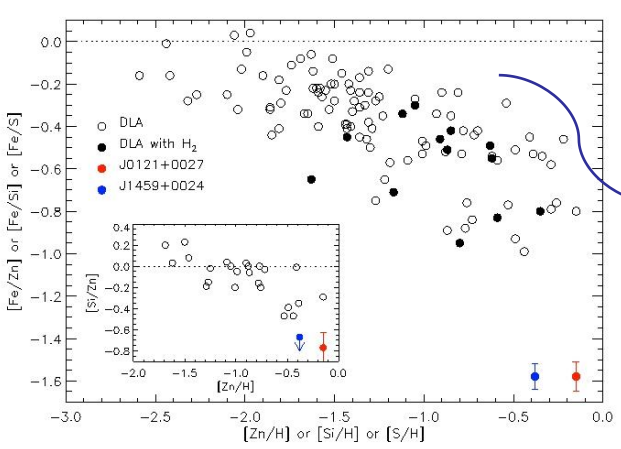
Velocity plots of the metal line transitions for absorption system at z=1.3947 towards quasar J1459+0024. The vertical thick blue dash lines are corresponding velocity=0 km/s at that redshift. (left panel)

Velocity plots of the metal line transitions for absorption system at z=1.3888 towards quasar J0121+0027. The vertical thick blue dash lines are corresponding velocity=0 km/s at that redshift. The thin blue dot line are corresponding velocity=-70 km/s at z=1.3888 to separate the two velocity components.





Dust depletions comparison with ISM in local group. The blue dots are relative abundance of absorption system towards quasar J1459+0024. The red dots are relative abundance, which are integrated over the whole line profiles of absorption system towards quasar J0121+0027 in velocity space. The empty squares are dust depletion patterns measured in SMC ISM; the black filled circles are patterns in LMC ISM; the empty triangles are patterns in cold Galactic disk clouds



Comparison of dust depletion, [Fe/Zn] and [Si/Zn], in this work with a DLA/sub-DLA sample. Dust-depletion factor, [Fe/X], and metallicity, [X/H], with X either Zn, S or Si. The empty circles are a combined DLA/sub-DLA sample having high resolution spectra (Prochaska et al. 2007 and Noterdaeme et al. 2008), while the black filled circles are H_2-bearing DLAs in the subsample from Noterdaeme et al. (2008). We assume N(HI)=10^{21} cm^{-2} in both of the absorbers.

Dust depletion and dust extinction features in 15 lines of sight in MW. (a): a moderate anti-correlation of dust depletion [Fe/H] and bump relative strength (Spearman's ρ=-0.46 for Galactic bumps solely; Spearman's ρ=-0.57 by including the average bumps of LMC and SMC). The empty triangle is the average LMC bump and the empty square is the average SMC bump. The dust depletion in LMC and SMC are measured by [Fe/Zn] ([Fe/H] are converted to [Fe/Zn] by assuming [Zn/H]=-0.3). (b): a weak correlation of the fraction of molecular hydrogen (f(H_2)) and bump relative strength (Spearman's ρ=+0.31). (c): a strong anti-correlation of [Fe/H] and f(H_2) in the Galactic absorbers (Spearman's ρ=-0.81). The vertical dotted line is [Fe/H]=-1.65 and the horizontal dotted line is f(H_2)=0.3. (d): a moderate correlation of [Fe/H] and dust-to-gas ratio (A_V/N(H_{total})) and dash line indicates the average Galactic ratio (Spearman's ρ=0.54).

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